IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. The best source of comparative pollutant release information is the Toxic Release Inventory (TRI). Pursuant to the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20 through 39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1995) TRI reporting year (which includes over 600 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries. TRI data provide the type, amount and media receptor of each chemical released or transferred.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1995 Toxic Release Inventory Public Data Release, reported onsite releases of toxic chemicals to the environment decreased by 5 percent (85.4 million pounds) between 1994 and 1995 (not including chemicals added and removed from the TRI chemical list during this period). Reported releases dropped by 46 percent between 1988 and 1995. Reported transfers of TRI chemicals to off-site locations increased by 0.4 percent (11.6 million pounds) between 1994 and 1995. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

Certain limitations exist regarding TRI data. Release and transfer reporting are limited to the approximately 600 chemicals on the TRI list. Therefore, a large portion of the emissions from industrial facilities are not captured by TRI. Within some sectors, (e.g. dry cleaning, printing and transportation equipment cleaning) the majority of facilities are not subject to TRI reporting because they are not considered manufacturing industries, or because they are

below TRI reporting thresholds. For these sectors, release information from other sources has been included. In addition, many facilities report more than one SIC code reflecting the multiple operations carried out onsite. Therefore, reported releases and transfers may or may not all be associated with the industrial operations described in this notebook.

The reader should also be aware that TRI "pounds released" data presented within the notebooks is not equivalent to a "risk" ranking for each industry. Weighting each pound of release equally does not factor in the relative toxicity of each chemical that is released. The Agency is in the process of developing an approach to assign toxicological weights to each chemical released so that one can differentiate between pollutants with significant differences in toxicity. As a preliminary indicator of the environmental impact of the industry's most commonly released chemicals, the notebook briefly summarizes the toxicological properties of the top five chemicals (by weight) reported by each industry.

Definitions Associated with Section IV Data Tables

General Definitions

SIC Code -- the Standard Industrial Classification (SIC) is a statistical classification standard used for all establishment-based Federal economic statistics. The SIC codes facilitate comparisons between facility and industry data.

TRI Facilities -- are manufacturing facilities that have 10 or more full-time employees and are above established chemical throughput thresholds. Manufacturing facilities are defined as facilities in Standard Industrial Classification primary codes 20-39. Facilities must submit estimates for all chemicals that are on the TRI list and are above throughput thresholds.

Data Table Column Heading Definitions

The following definitions are based upon standard definitions developed by EPA's Toxic Release Inventory Program. The categories below represent the possible pollutant destinations that can be reported.

RELEASES -- are an on-site discharge of a toxic chemical to the environment. This includes emissions to the air, discharges to bodies of water, releases at the facility to land, as well as contained disposal into underground injection wells.

Releases to Air (Point and Fugitive Air Emissions) -- Include all air emissions from industry activity. Point emissions occur through confined air

streams as found in stacks, vents, ducts, or pipes. Fugitive emissions include equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems.

Releases to Water (Surface Water Discharges) -- encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Releases due to runoff, including storm water runoff, are also reportable to TRI.

Releases to Land -- occur within the boundaries of the reporting facility. Releases to land include disposal of toxic chemicals in landfills, land treatment/application farming, surface impoundments, and other land disposal methods (such as spills, leaks, or waste piles).

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells. Class I wells are used to inject liquid hazardous wastes or dispose of industrial and municipal wastewaters beneath the lowermost underground source of drinking water. Class V wells are generally used to inject non-hazardous fluid into or above an underground source of drinking water. TRI reporting does not currently distinguish between these two types of wells, although there are important differences in environmental impact between these two methods of injection.

TRANSFERS -- is a transfer of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. Chemicals reported to TRI as transferred are sent to off-site facilities for the purpose of recycling, energy recovery, treatment, or disposal. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, the reported quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewater transferred through pipes or sewers to a publicly owned treatments works (POTW). Treatment or removal of a chemical from the wastewater depend on the nature of the chemical, as well as the treatment methods present at the POTW. Not all TRI chemicals can be treated or removed by a POTW. Some chemicals, such as metals, may be removed, but are not destroyed and may be disposed of in landfills or discharged to receiving waters.

Transfers to Recycling -- are sent off-site for the purposes of regenerating or recovery by a variety of recycling methods, including solvent recovery, metals recovery, and acid regeneration. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site to be treated through a variety of methods, including neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Pharmaceutical Industry

This section summarizes TRI data of pharmaceutical facilities reporting SIC codes 2833 and 2834 as the primary SIC code for the facility. Of the 916 pharmaceutical establishments reported by the *1992 Census of Manufacturers*, 200 reported to TRI in 1995.

According to 1995 TRI data, the reporting facilities released (discharged to the air, water, or land without treatment) and transferred (shipped off-site) a total of 177 million pounds of pollutants, made up of 104 different chemicals. This represents about 3 percent of the 5.7 billion pounds of TRI chemicals released and transferred by all manufacturers that year. In comparison, the chemical industry (SIC 28) as a whole produced 1.7 billion pounds that year, accounting for about 30 percent of all releases and transfers.

Of the pharmaceutical industry's TRI releases, 57 percent go to the air, 25 percent to underground injection, 17 percent to surface waters, and 1 percent to the land. This release profile differs from other TRI industries which average approximately 59 percent to air, 30 percent to water, and 10 percent to land. Table 14 lists the pharmaceutical industry's TRI reported chemical releases.

Of the pharmaceutical industry's transfers, about 55 percent are transferred for energy recovery off-site, 19 percent for treatment off-site, 13 percent are transferred to POTWs, 12 percent for recycling off-site, and about 1 percent for disposal off-site. Table 15 lists the pharmaceutical industry's TRI reported toxic chemical transfers.

Of the top ten most frequently reported toxic chemicals on the TRI list, the prevalence of volatile chemicals explains the air intensive toxic chemical loading of the pharmaceutical industry. Seven of the ten most commonly reported toxic chemicals are highly volatile. Six of the ten are volatile organic compounds (methanol, dichloromethane, toluene, ethylene glycol, N,N-Dimethylformamide, and acetonitrile). These are primarily solvents used to extract active ingredients and for cleaning equipment. The primary means of release to the environment are from fugitive air and point air sources. Large quantities of methanol, N,N-Dimethylformamide, and acetonitrile, however, are released via underground injection. Other commonly reported chemicals released and transferred are acids (hydrochloric, sulfuric, and phosphoric) which can be used for pH control or as catalysts.

Table 14: 1995 Releases for Pharmaceutical Facilities (SIC 2833 & 2834) in TRI, by Number of Facilities Reporting (Releases reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
METHANOL	104	1,396,868	2,100,445	841,250	5,820,000	1,370	10,159,933	97,692
DICHLOROMETHANE	63	2,386,889	4,611,794	21,635	83,000	5	7,103,323	112,751
HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	62	68,269	532,143	10	0	5	600,427	9,684
TOLUENE	54	498,932	593,839	10,025	9,100	0	1,111,896	20,591
AMMONIA	42	772,824	380,822	1,665,336	0	232,413	3,051,395	72,652
PHOSPHORIC ACID	31	5,194	5,160	20	0	5	10,379	335
ETHYLENE GLYCOL	30	21,721	2,638	20,200	0	500	45,059	1,502
ACETONITRILE	25	206,608	106,670	1,405	219,000	5	533,688	21,348
N,N-DIMETHYLFORMAMIDE	20	63,972	10,598	69,005	1,000,000	1,700	1,145,275	57,264
CHLORINE	19	4,315	9,036	16,633	0	5	29,989	1,578
N-HEXANE	18	201,267	258,124	2,384	5,300	5	467,080	25,949
TRIETHYLAMINE	17	22,262	15,957	10,030	5,900	5	54,154	3,186
ZINC COMPOUNDS	16	765	11,169	73,686	100,000	121,500	307,120	19,195
CHLOROFORM	14	55,536	88,826	3,105	0	0	147,467	10,533
N-BUTYL ALCOHOL	14	145,024	476,734	255	6,600	0	628,613	44,901
METHYL ISOBUTYL KETONE	14	273,952	109,175	15,000	6,500	0	404,627	28,902
XYLENE (MIXED ISOMERS)	14	10,712	107,105	0	0	0	117,817	8,416
FORMIC ACID	13	21,550	3,173	5,160	1,400	5	31,288	2,407
NITRIC ACID	13	8,029	12,928	10	0	0	20,967	1,613
METHYL TERT-BUTYL ETHER	11	4,061	18,449	0	12,000	0	34,510	3,137
SULFURIC ACID	11	22,283	3,091	0	0	0	25,374	2,307
NITRATE COMPOUNDS	10	0	0	2,082,243	0	16,875	2,099,118	209,912
FORMALDEHYDE	9	2,662	3,772	2,000	0	0	8,434	937
CYCLOHEXANE	9	47,574	147,052	700	33,000	0	228,326	25,370
DICHLORODIFLUOROMETHANE	8	22,610	195,178	0	0	0	217,788	27,224
CERTAIN GLYCOL ETHERS	7	1,310	27,944	5	0	0	29,259	4,180
TERT-BUTYL ALCOHOL	7	26,713	19,473	2,400	36,000	0	84,586	12,084
METHYL ETHYL KETONE	7	20,624	51,120	50	31,000	0	102,794	14,685
NAPHTHALENE	7	515	1,014	0	0	0	1,529	218
PYRIDINE	7	2,820	3,093	5	13,000	0	18,918	2,703
COPPER COMPOUNDS	6	6	67	0	0	0	73	12

Table 14, cont.: 1995 Releases for Pharmaceutical Facilities (SICs 2833 & 2934), in TRI by Number of Facilities Reporting (Releases reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
COPPER COMPOUNDS	6	6	67	0	0	0	73	12
CYANIDE COMPOUNDS	6	425	868	5,810	2,800	0	9,903	1,651
MANGANESE COMPOUNDS	6	260	1,005	26,905	0	505	28,675	4,779
CHLOROMETHANE	6	28,840	97,844	44,000	0	0	170,684	28,447
TRICHLOROFLUOROMETHANE	6	59,306	61,801	0	0	0	121,107	20,185
DI(2-ETHYLHEXYL) PHTHALATE	6	255	292	0	0	0	547	91
ETHYLBENZENE	5	789	977	0	0	0	1,766	353
1,2-DICHLOROETHANE	5	928	1,313	269	10,000	0	12,510	2,502
2-METHOXYETHANOL	5	9,130	9,455	0	0	0	18,585	3,717
BROMINE	5	780	389	10	0	5	1,184	237
ARSENIC COMPOUNDS	4	5	10	0	0	0	15	4
NICKEL COMPOUNDS	4	0	75	434	0	96	605	151
CHLORODIFLUOROMETHANE	4	31,484	30,009	0	0	0	61,493	15,373
CHLOROACETIC ACID	4	24	5	16	0	0	45	11
BENZOYL PEROXIDE	4	0	0	0	0	0	0	0
SODIUM NITRITE	4	0	0	15,000	0	0	15,000	3,750
BARIUM COMPOUNDS	3	10	5	250	0	0	265	88
ANILINE	3	3,896	1,173	0	0	0	5,069	1,690
BENZENE	3	2,970	582	0	760	0	4,312	1,437
ETHYLENE OXIDE	3	12,143	9,550	0	0	0	21,693	7,231
DICHLOROTETRAFLUOROETHANE (CFC-114)	3	4,978	2,260	0	0	0	7,238	2,413
PERACETIC ACID	3	255	5	5	0	5	270	90
HYDRAZINE	3	285	50	3	0	0	338	113
OZONE	3	250	522	0	0	0	772	257
TETRACYCLINE HYDROCHLORIDE	2	0	754	0	0	0	754	377
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	2	61,250	140,250	0	0	0	201,500	100,750
METHYL IODIDE	2	1,100	850	0	0	0	1,950	975
PROPYLENE OXIDE	2	500	1,330	5	0	0	1,835	918
FREON 113	2	3,500	38,119	0	0	0	41,619	20,810
ACRYLIC ACID	2	33	22	0	0	0	55	28
PHTHALIC ANHYDRIDE	2	1	0	0	0	0	1	1

Table 14, cont.: 1995 Releases for Pharmaceutical Facilities (SICs 2833 & 2934) in TRI, by Number of Facilities Reporting (Releases reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
BENZOYL CHLORIDE	2	0	2	0	0	0	2	1
BENZYL CHLORIDE	2	5	5	0	0	0	10	5
EPICHLOROHYDRIN	2	290	50	0	0	0	340	170
M-XYLENE	2	1,565	571	250	0	0	2,386	1,193
PHENOL	2	255	255	0	0	0	510	255
DIETHANOLAMINE	2	500	1,000	5	0	0	1,505	753
1,4-DIOXANE	2	270	260	0	0	0	530	265
DIMETHYLAMINE	2	23,500	15,250	250	0	250	39,250	19,625
TETRACHLOROETHYLENE	2	2,239	14,000	0	0	0	16,239	8,120
DIAZINON	2	5	278	5	0	0	288	144
ZINC (FUME OR DUST)	2	0	2	0	0	0	2	1
TITANIUM TETRACHLORIDE	2	5	10	0	0	0	15	8
HYDROGEN FLUORIDE	2	250	8,350	0	0	0	8,600	4,300
ABAMECTIN	2	0	0	16	0	0	16	8
ANTIMONY COMPOUNDS	1	5	5	0	0	0	10	10
CHROMIUM COMPOUNDS	1	0	0	0	43,000	0	43,000	43,000
COBALT COMPOUNDS	1	0	0	0	0	0	0	0
SELENIUM COMPOUNDS	1	0	3	0	0	0	3	3
FAMPHUR	1	0	0	0	0	0	0	0
CARBON TETRACHLORIDE	1	60	400	67	0	0	527	527
PHENYTOIN	1	0	0	0	0	0	0	0
DICHLORVOS	1	5	250	5	0	0	260	260
1,1,1-TRICHLOROETHANE	1	76,500	52,500	0	0	0	129,000	129,000
BROMOMETHANE	1	50	21	0	0	0	71	71
CHLOROETHANE	1	163	0	0	0	0	163	163
CARBON DISULFIDE	1	2,450	21,000	0	0	0	23,450	23,450
PHOSGENE	1	240	5	0	5	0	250	250
DIMETHYL SULFATE	1	0	8	0	0	0	8	8
ISOBUTYRALDEHYDE	1	11	25	0	0	0	36	36
SEC-BUTYL ALCOHOL	1	250	71,799	0	0	0	72,049	72,049
METHYL CHLOROCARBONATE	1	250	0	5	0	5	260	260
QUINOLINE	1	5	0	5	0	5	15	15

Table 14, cont.: 1995 Releases for Pharmaceutical Facilities (SICs 2833 & 2934) in TRI, by Number of Facilities Reporting (Releases reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
BIPHENYL	1	5	0	0	0	0	5	5
O-XYLENE	1	2,400	54	0	0	0	2,454	2,454
1,2-DICHLOROBENZENE	1	244	2,490	0	0	0	2,734	2,734
1,2,4-TRIMETHYLBENZENE	1	250	250	5	0	0	505	505
CUMENE	1	250	250	5	0	0	505	505
ACETOPHENONE	1	5	5	0	0	0	10	10
NITROBENZENE	1	3,891	321	0	0	0	4,212	4,212
ALLYL CHLORIDE	1	321	27	0	0	0	348	348
CHLOROMETHYL METHYL ETHER	1	0	0	0	0	0	0	0
MALEIC ANHYDRIDE	1	5	5	0	5	0	15	15
CHLOROBENZENE	1	12	11	0	0	0	23	23
CYCLOHEXANOL	1	93	133	0	0	0	226	226
2-ETHOXYETHANOL	1	29	91	0	0	0	120	120
PROPYLENE	1	5	5	0	0	0	10	10
N,N-DIMETHYLANILINE	1	5	35	0	0	0	40	40
MALATHION	1	0	2	0	0	0	2	2
THIABENDAZOLE	1	175	3,504	0	0	0	3,679	3,679
ETHYL CHLOROFORMATE	1	250	250	5	0	5	510	510
1,3-DICHLOROBENZENE	1	1,200	80	0	0	0	1,280	1,280
LITHIUM CARBONATE	1	0	0	0	0	0	0	0
N-METHYL-2-PYRROLIDONE	1	7	0	0	0	0	7	7
TETRACHLORVINPHOS	1	5	5	5	0	0	15	15
TRIFLURALIN	1	6,900	250	0	0	0	7,150	7,150
BENFLURALIN	1	750	250	0	0	0	1,000	1,000
PROMETRYN	1	0	0	0	0	0	0	0
NICKEL	1	0	0	250	0	0	250	250
THIOPHANATE-METHYL	1	0	187	0	0	0	187	187
SODIUM AZIDE	1	0	0	0	0	0	0	0
VINCLOZOLIN	1	0	0	0	0	0	0	0
PERMETHRIN	1	0	0	0	0	0	0	0
PROPICONAZOLE	1	0	0	0	0	0	0	0
	200	6,664,939	10,500,358	4,936,137	7,438,370	375,274	29,915,078	149,575

Table 15: 1995 Transfers for Pharmaceutical Facilities (SICs 2833 & 2834) in TRI, by Number and Facilities Reporting (Transfers reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
METHANOL	104	10,078,077	15,765	2,895,743	6,162,576	45,367,761	64,531,571	620,496
DICHLOROMETHANE	63	751,775	16,824	5,012,106	7,276,313	1,235,911	14,292,929	226,872
HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	62	1,760	0	40	42,681	50	44,531	718
TOLUENE	54	414,049	1,561	3,339,411	6,122,272	19,740,070	29,617,363	548,470
AMMONIA	42	1,071,827	1,465	.	112,847	9,600	1,195,739	28,470
PHOSPHORIC ACID	31	3,105	0	.	57	.	3,162	102
ETHYLENE GLYCOL	30	554,598	3,852	336,439	61,127	77,350	1,033,366	34,446
ACETONITRILE	25	95,246	1	2,069,030	3,383,572	2,740,790	8,288,639	331,546
N,N-DIMETHYLFORMAMIDE	20	183,581	139,701	148,797	237,849	1,603,998	2,313,926	115,696
CHLORINE	19	5	.	.	.	.	5	0
N-HEXANE	18	12,278	2,700	240,109	1,441,312	1,138,050	2,834,449	157,469
TRIETHYLAMINE	17	187,407	12	3,600	198,784	247,722	637,525	37,501
ZINC COMPOUNDS	16	9,575	750,130	.	22,330	5,957	787,992	49,250
CHLOROFORM	14	106,977	750	44,703	702,085	30,985	885,500	63,250
N-BUTYL ALCOHOL	14	489,700	1	.	107,940	953,422	1,551,063	110,790
METHYL ISOBUTYL KETONE	14	260,567	0	1,573	230,440	1,016,450	1,509,030	107,788
XYLENE (MIXED ISOMERS)	14	7,961	.	250	9,823	1,572,510	1,590,544	113,610
FORMIC ACID	13	86,010	.	.	37,750	29	123,789	9,522
NITRIC ACID	13	5	.	250,803	339	.	251,147	19,319
METHYL TERT-BUTYL ETHER	11	27,370	0	.	278,900	1,070,683	1,376,953	125,178
SULFURIC ACID	11	0	.	.	.	.	0	0
NITRATE COMPOUNDS	10	100,018	.	.	135	.	100,153	10,015
FORMALDEHYDE	9	251,529	3,650	.	190	.	255,369	28,374
CYCLOHEXANE	9	755	600	250	15,100	311,350	328,055	36,451
DICHLORODIFLUOROMETHANE	8	0	.	95,320	137,292	.	232,612	29,077
CERTAIN GLYCOL ETHERS	7	146,087	.	.	26	312,401	458,514	65,502
TERT-BUTYL ALCOHOL	7	6,066	4,950	.	251	425,850	437,117	62,445
METHYL ETHYL KETONE	7	1,190	.	750	5,432	260,702	268,074	38,296
NAPHTHALENE	7	0	0	.	92	435	527	75
PYRIDINE	7	207,128	5	11,765	2,937	92,177	314,012	44,859
COPPER COMPOUNDS	6	467	1,410	.	9,300	.	11,427	1,905

Table 15, cont.: 1995 Transfers for Pharmaceutical Facilities (SICs 2833 & 2834) in TRI, by Number and Facilities Reporting (Transfers reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
CYANIDE COMPOUNDS	6	285	.	.	104	.	389	65
MANGANESE COMPOUNDS	6	6,650	8,116	.	500	.	15,266	2,544
CHLOROMETHANE	6	20	.	.	42	.	62	10
TRICHLOROFLUOROMETHANE	6	0	.	104,310	233,270	167,833	505,413	84,236
DI(2-ETHYLHEXYL) PHTHALATE	6	281	13,698	2,912,911	.	647	2,927,537	487,923
ETHYLBENZENE	5	316	.	.	3,266	74,215	77,797	15,559
1,2-DICHLOROETHANE	5	3,124	250	100,597	2,074	36,300	142,345	28,469
2-METHOXYETHANOL	5	976,200	.	.	.	1,524,333	2,500,533	500,107
BROMINE	5	2,640,807	259,632	.	.	.	2,900,439	580,088
ARSENIC COMPOUNDS	4	60	7,494	.	3,608	.	11,162	2,791
NICKEL COMPOUNDS	4	0	422	83,180	14	.	83,616	20,904
CHLORODIFLUOROMETHANE	4	0	.	.	.	.	0	0
CHLOROACETIC ACID	4	0	.	.	2,628	.	2,628	657
BENZOYL PEROXIDE	4	1,502	250	.	2,797	1,303	5,852	1,463
SODIUM NITRITE	4	124,660	.	.	13,009	.	137,669	34,417
BARIUM COMPOUNDS	3	170	58	.	14	.	242	81
ANILINE	3	2,500	11,833	.	24,922	867	40,122	13,374
BENZENE	3	523	20	.	96,050	335,350	431,943	143,981
ETHYLENE OXIDE	3	0	.	.	750	.	750	250
DICHLOROTETRAFLUOROETHANE (CFC-114)	3	0	.	1,689	15,787	.	17,476	5,825
PERACETIC ACID	3	0	.	.	.	.	0	0
HYDRAZINE	3	0	.	.	.	.	0	0
OZONE	3	0	.	.	.	.	0	0
TETRACYCLINE HYDROCHLORIDE	2	1,256	112	.	500	.	1,868	934
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	2	1,300	.	.	.	.	1,300	650
METHYL IODIDE	2	0	.	.	.	.	0	0
PROPYLENE OXIDE	2	20,750	.	.	.	180	20,930	10,465
FREON 113	2	0	.	.	16,000	62	16,062	8,031
ACRYLIC ACID	2	0	.	.	2,758	.	2,758	1,379
PHTHALIC ANHYDRIDE	2	0	.	.	.	.	0	0
BENZOYL CHLORIDE	2	0	.	.	.	.	0	0

Table 15, cont.: 1995 Transfers for Pharmaceutical Facilities (SICs 2833 & 2834) in TRI, by Number and Facilities Reporting (Transfers reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
BENZYL CHLORIDE	2	5	.	.	10	.	15	8
EPICHLOROHYDRIN	2	0	0	.	.	.	0	0
M-XYLENE	2	20	.	.	87,148	78,059	165,227	82,614
PHENOL	2	250	.	.	548	.	798	399
DIETHANOLAMINE	2	1,500	.	.	.	47,916	49,416	24,708
1,4-DIOXANE	2	4,170	2	.	300	8,960	13,432	6,716
DIMETHYLAMINE	2	0	38,000	.	2,100	.	40,100	20,050
TETRACHLOROETHYLENE	2	0	.	510	.	49,005	49,515	24,758
DIAZINON	2	0	1,060	.	1,609	.	2,669	1,335
ZINC (FUME OR DUST)	2	0	1,223	.	.	.	1,223	612
TITANIUM TETRACHLORIDE	2	0	.	.	.	.	0	0
HYDROGEN FLUORIDE	2	0	.	.	.	.	0	0
ABAMECTIN	2	0	.	.	5,582	.	5,582	2,791
ANTIMONY COMPOUNDS	1	0	53,200	.	.	.	53,200	53,200
CHROMIUM COMPOUNDS	1	250	260	.	5	.	515	515
COBALT COMPOUNDS	1	2,920	.	.	.	.	2,920	2,920
SELENIUM COMPOUNDS	1	260	.	.	13,641	.	13,901	13,901
FAMPHUR	1	0	.	.	1,540	.	1,540	1,540
CARBON TETRACHLORIDE	1	40	.	.	45,782	.	45,822	45,822
PHENYTOIN	1	0	19,300	.	.	.	19,300	19,300
DICHLORVOS	1	0	250	.	250	.	500	500
1,1,1-TRICHLOROETHANE	1	0	.	106,250	.	.	106,250	106,250
BROMOMETHANE	1	0	.	.	.	.	0	0
CHLOROETHANE	1	0	.	.	2,489	.	2,489	2,489
CARBON DISULFIDE	1	1,120	.	.	18	11,390	12,528	12,528
PHOSGENE	1	0	.	.	.	.	0	0
DIMETHYL SULFATE	1	0	.	.	.	.	0	0
ISOBUTYRALDEHYDE	1	0	.	8,647	640	.	9,287	9,287
SEC-BUTYL ALCOHOL	1	0	.	.	.	.	0	0
METHYL CHLOROCARBONATE	1	0	.	.	.	.	0	0
QUINOLINE	1	0	.	.	250	.	250	250

Table 15, cont.: 1995 Transfers for Pharmaceutical Facilities (SICs 2833 & 2834) in TRI, by Number and Facilities Reporting (Transfers reported in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
BIPHENYL	1	0	.	.	.	.	0	0
O-XYLENE	1	0	.	.	100,000	61,800	161,800	161,800
1,2-DICHLOROBENZENE	1	6,480	.	.	14,000	91,891	112,371	112,371
1,2,4-TRIMETHYLBENZENE	1	4,800	.	.	.	.	4,800	4,800
CUMENE	1	1,167	.	.	.	.	1,167	1,167
ACETOPHENONE	1	0	.	.	.	.	0	0
NITROBENZENE	1	5	.	.	5,914	.	5,919	5,919
ALLYL CHLORIDE	1	0	.	.	.	.	0	0
CHLOROMETHYL METHYL ETHER	1	0	.	.	.	.	0	0
MALEIC ANHYDRIDE	1	0	.	.	.	.	0	0
CHLOROBENZENE	1	0	.	.	.	179,228	179,228	179,228
CYCLOHEXANOL	1	0	.	.	.	.	0	0
2-ETHOXYETHANOL	1	4	.	.	25,004	.	25,008	25,008
PROPYLENE	1	0	.	.	.	.	0	0
N,N-DIMETHYLANILINE	1	10,000	.	.	.	328,000	338,000	338,000
MALATHION	1	0	26	.	273	.	299	299
THIABENDAZOLE	1	271	.	.	.	2,160	2,431	2,431
ETHYL CHLOROFORMATE	1	0	.	.	.	.	0	0
1,3-DICHLOROBENZENE	1	1,400	.	.	.	.	1,400	1,400
LITHIUM CARBONATE	1	0	.	.	750	.	750	750
N-METHYL-2-PYRROLIDONE	1	249,000	.	.	.	.	249,000	249,000
TETRACHLORVINPHOS	1	0	4,200	.	.	.	4,200	4,200
TRIFLURALIN	1	0	18,000	.	.	.	18,000	18,000
BENFLURALIN	1	0	14,000	.	.	.	14,000	14,000
PROMETRYN	1	0	.	.	203	.	203	203
NICKEL	1	0	18	400,000	.	.	400,018	400,018
THIOPHANATE-METHYL	1	0	.	.	2,677	.	2,677	2,677
SODIUM AZIDE	1	0	.	.	.	.	0	0
VINCLOZOLIN	1	0	.	.	1,030	.	1,030	1,030
PERMETHRIN	1	0	.	.	.	.	0	0
PROPICONAZOLE	1	0	.	.	1,025	.	1,025	1,025
	200	19,119,179	1,394,801	18,168,783	27,330,633	81,213,752	147,239,047	736,195

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases. The top reporting facilities for the pharmaceutical industry are listed below in Tables 16. Facilities that have reported only the SIC codes covered under this notebook as a primary SIC code appear on the first list. Table 17 contains additional facilities that have reported the SIC code covered within this report, and one or more SIC codes that are not within the scope of this notebook. Therefore, the second list includes facilities that conduct multiple operations -- some that are under the scope of this notebook, and some that are not. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Table 16: Top 10 TRI Releasing Pharmaceutical Manufacturing Facilities[a]

Rank	Facility	Total TRI Releases in Pounds
1	Pharmacia & Upjohn Co., Portage, Michigan	8,307,190
2	Warner-Lambert Co., Holland, Michigan	2,594,111
3	Eli Lilly & Co. - Tippecanoe Labs, Shadeland, Indiana	2,504,810
4	Upjohn Mfg., Co., Barceloneta, Puerto Rico	2,001,450
5	Pfizer Inc., Groton, Connecticut.	1,761,385
6	Eli Lilly & Co - Clinton Laboratories, Clinton, Indiana	1,282,605
7	Abbott Chemicals, Inc., Barceloneta, Puerto Rico	1,193,707
8	Pfizer Inc., Southport, North Carolina	1,164,350
9	Schering-Plough Products, Inc., Las Piedras, Puerto Rico	756,089
10	Biokyowa Inc., Cape Girardeau, Missouri	669,869

Source: *US EPA 1995 Toxics Release Inventory Database.*

[a] Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

Table 17: Top 10 TRI Releasing Facilities Reporting Pharmaceutical Manufacturing SIC Codes to TRI[a]

Rank	SIC Codes Reported in TRI	Facility	Total TRI Releases in Pounds
1	2834	Pharmacia & Upjohn Co., Portage, Michigan	8,307,190
2	2819, 2834, 2842, 2865, 2869, 2873, 2879	Monsanto Co., Luling, Louisiana	5,698,031
3	2834	Warner-Lambert Co., Holland, Michigan	2,594,111
4	2834	Eli Lilly & Co. - Tippecanoe Labs, Shadeland, Indiana	2,504,810
5	2834	Upjohn Mfg., Co., Barceloneta, Puerto Rico	2,001,450
6	2833	Pfizer Inc., Groton, Connecticut.	1,761,385
7	2834, 2869, 2969	Ethyl Corp., Orangeburg, South Carolina	1,284,456
8	2833, 2834	Eli Lilly & Co - Clinton Laboratories, Clinton, Indiana	1,282,605
9	2819, 2821, 2824, 2834, 2865, 2869, 2879, 2979	Dow Chemical Co., Midland, Michigan	1,228,629
10	2833, 2834	Abbott Chemicals, Inc., Barceloneta, Puerto Rico	1,193,707

Source: *US EPA Toxics Release Inventory Database, 1995.*

[a] Being included on this list does not mean that the release is associated with non-compliance with environmental laws.

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that facilities within both SIC 2833 and 2834 self-reported as released to the environment based upon 1994 TRI data. Because this section is based upon self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals. Information regarding pollutant release reductions over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section VIII of this document. Since these descriptions are cursory, please consult the sources referenced below for a more detailed description of both the chemicals described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.A.

The brief descriptions provided below were taken from the Hazardous Substances Data Bank (HSDB) and the Integrated Risk Information System (IRIS). The discussions of toxicity describe the range of possible adverse health effects that have been found to be associated with exposure to these chemicals. These adverse effects may or may not occur at the levels released to the environment. Individuals interested in a more detailed picture of the chemical concentrations associated with these adverse effects should consult a toxicologist or the toxicity literature for the chemical to obtain more information. The effects listed below must be taken in context of these exposure assumptions that are more fully explained within the full chemical profiles in HSDB. For more information on TOXNET[a] , contact the TOXNET help line at 1-800-231-3766.

Methanol (CAS: 67-56-1)

Toxicity. Methanol is readily absorbed by the gastrointestinal tract and the respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels

[a] TOXNET is a computer system run by the National Library of Medicine that includes a number of toxicological databases managed by EPA, National Cancer Institute, and the National Institute for Occupational Safety and Health. For more information on TOXNET, contact the TOXNET help line at 800-231-3766. Databases included in TOXNET are: CCRIS (Chemical Carcinogenesis Research Information System), DART (Developmental and Reproductive Toxicity Database), DBIR (Directory of Biotechnology Information Resources), EMICBACK (Environmental Mutagen Information Center Backfile), GENE-TOX (Genetic Toxicology), HSDB (Hazardous Substances Data Bank), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TRI (Toxic Chemical Release Inventory). HSDB contains chemical-specific information on manufacturing and use, chemical and physical properties, safety and handling, toxicity and biomedical effects, pharmacology, environmental fate and exposure potential, exposure standards and regulations, monitoring and analysis methods, and additional references.

generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals.

Ecologically, methanol is expected to have low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed one mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that methanol is carcinogenic.

Environmental Fate. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Methanol is readily degraded by microorganisms in soils and surface waters.

Physical Properties. Methanol is a colorless, highly flammable liquid. Methanol is miscible in water and has a boiling point of 147 degrees F.

Methylene Chloride (Dichloromethane) (CAS: 75-09-2)

Toxicity. Short-term exposure to methylene chloride (MC) is associated with central nervous system effects, including headaches, giddiness, stupor, irritability, and numbness, and tingling in the limbs. More severe neurological effects are reported from longer-term exposure, apparently due to increased carbon monoxide in the blood from the break down of MC. Contact with MC causes irritation of the eyes, skin, and respiratory tract.

Occupational exposure to MC has also been linked to increased incidence of spontaneous abortions in women. Acute damages to the eyes and upper respiratory tract, unconsciousness, and death were reported in workers exposed to high concentrations of MC. Phosgene (a degradation product of MC) poisoning has been reported to occur in several cases where MC was used in the presence of an open fire.

Populations at special risk from exposure to MC include obese people (due to accumulation of MC in fat), and people with impaired cardiovascular systems.

Carcinogenity. MC is a probable human carcinogen via both inhalation and oral exposure, based on limited evidence in humans, and sufficient evidence in animals.

Environmental Fate. When spilled on land, MC is rapidly lost from the soil surface through volatilization. The remainder leaches through the subsoil into the groundwater.

Biodegradation is possible in natural waters but will probably be very slow compared with evaporation. Little is known about bioconcentration in aquatic organisms or adsorption to sediments but these are not likely to be significant processes. Hydrolysis is not an important process under normal environmental conditions.

MC released into the atmosphere degrades via contact with other gases with a half-life of several months. A small fraction of the chemical diffuses to the stratosphere where it rapidly degrades through exposure to ultraviolet radiation and contact with chlorine ions. Being a moderately soluble chemical, MC is expected to partially return to earth in rain.

Physical Properties. Methylene chloride is a colorless liquid. It is soluble to 2 percent in water and has a boiling point of 104 degrees F.

Ammonia[a] *(CAS: 7664-41-7)*

Toxicity. Anhydrous ammonia is irritating to the skin, eyes, nose, throat, and upper respiratory system.

Ecologically, ammonia is a source of nitrogen (an essential element for aquatic plant growth), and may therefore contribute to eutrophication of standing or slow-moving surface water, particularly in nitrogen-limited waters such as the Chesapeake Bay. In addition, aqueous ammonia is moderately toxic to aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that ammonia is carcinogenic.

Environmental Fate. Ammonia combines with sulfate ions in the atmosphere and is washed out by rainfall, resulting in rapid return of ammonia to the soil and surface waters.

Ammonia is a central compound in the environmental cycling of nitrogen. Ammonia in lakes, rivers, and streams is converted to nitrate.

[a] The reporting standards for ammonia were changed in 1995. Ammonium sulfate is deleted from the list and threshold and release determinations for aqueous ammonia are limited to 10 percent of the total ammonia present in solution. This change will reduce the amount of ammonia reported to TRI. Complete details of the revisions can be found in 40 CFR Part 372.

Physical Properties. Ammonia is a colorless gas at atmospheric pressure, but is shipped as a liquefied compressed gas. It is soluble to about 34 percent in water and has a boiling point of -28 degrees F. Ammonia It is corrosive and has a pungent odor.

Toluene (CAS: 108-88-3)

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also affect the way the kidneys and liver function.

Reactions of toluene (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Some studies have shown that unborn animals were harmed when high levels of toluene were inhaled by their mothers, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar difficulties in humans.

Carcinogenicity. There is currently no evidence to suggest that toluene is carcinogenic.

Environmental Fate. A portion of releases of toluene to land and water will evaporate. Toluene may also be degraded by microorganisms. Once volatilized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.

Physical Properties. Toluene liquid with a sweet, pungent odor. It is soluble to 0.07 percent in water and has a boiling point of 232 degrees F.

IV.C. Other Data Sources

The toxic chemical release data obtained from TRI captures many of the facilities in the pharmaceutical industry. It also allows for a comparison across years and industry sectors. Reported chemicals are limited however to the approximately 600 reported chemicals. Most of the hydrocarbon emissions from pharmaceutical facilities are not captured by TRI. The EPA Office of Air Quality Planning and Standards has compiled air pollutant emission factors for determining the total air emissions of priority pollutants (e.g., total hydrocarbons, SO_2, NO_2, CO, particulates, etc.) from many chemical manufacturing sources.

The EPA Office of Air's Aerometric Information Retrieval System (AIRS) contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Table 18 summarizes annual releases of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of 10 microns or less (PM_{10}), total particulate (PT), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).

Table 18: Air Pollutant Releases by Industry Sector (tons/year)

Industry Sector	CO	NO_2	PM_{10}	PT	SO_2	VOC
Metal Mining	4,670	39,849	63,541	173,566	17,690	915
Nonmetal Mining	25,922	22,881	40,199	128,661	18,000	4,002
Lumber and Wood Production	122,061	38,042	20,456	64,650	9,401	55,983
Furniture and Fixtures	2,754	1,872	2,502	4,827	1,538	67,604
Pulp and Paper	566,883	358,675	35,030	111,210	493,313	127,809
Printing	8,755	3,542	405	1,198	1,684	103,018
Inorganic Chemicals	153,294	106,522	6,703	34,664	194,153	65,427
Organic Chemicals	112,410	187,400	14,596	16,053	176,115	180,350
Petroleum Refining	734,630	355,852	27,497	36,141	619,775	313,982
Rubber and Misc. Plastics	2,200	9,955	2,618	5,182	21,720	132,945
Stone, Clay and Concrete	105,059	340,639	192,962	662,233	308,534	34,337
Iron and Steel	1,386,461	153,607	83,938	87,939	232,347	83,882
Nonferrous Metals	214,243	31,136	10,403	24,654	253,538	11,058
Fabricated Metals	4,925	11,104	1,019	2,790	3,169	86,472
Electronics and Computers	356	1,501	224	385	741	4,866
Motor Vehicles, Bodies, Parts and Accessories	15,109	27,355	1,048	3,699	20,378	96,338
Dry Cleaning	102	184	3	27	155	7,441
Ground Transportation	128,625	550,551	2,569	5,489	8,417	104,824
Metal Casting	116,538	11,911	10,995	20,973	6,513	19,031
Pharmaceuticals	**6,586**	**19,088**	**1,576**	**4,425**	**21,311**	**37,214**
Plastic Resins and Manmade Fibers	16,388	41,771	2,218	7,546	67,546	74,138
Textiles	8,177	34,523	2,028	9,479	43,050	27,768
Power Generation	366,208	5,986,757	140,760	464,542	13,827,511	57,384
Shipbuilding and Repair	105	862	638	943	3,051	3,967

Source: U.S. EPA Office of Air and Radiation, AIRS Database, 1997.

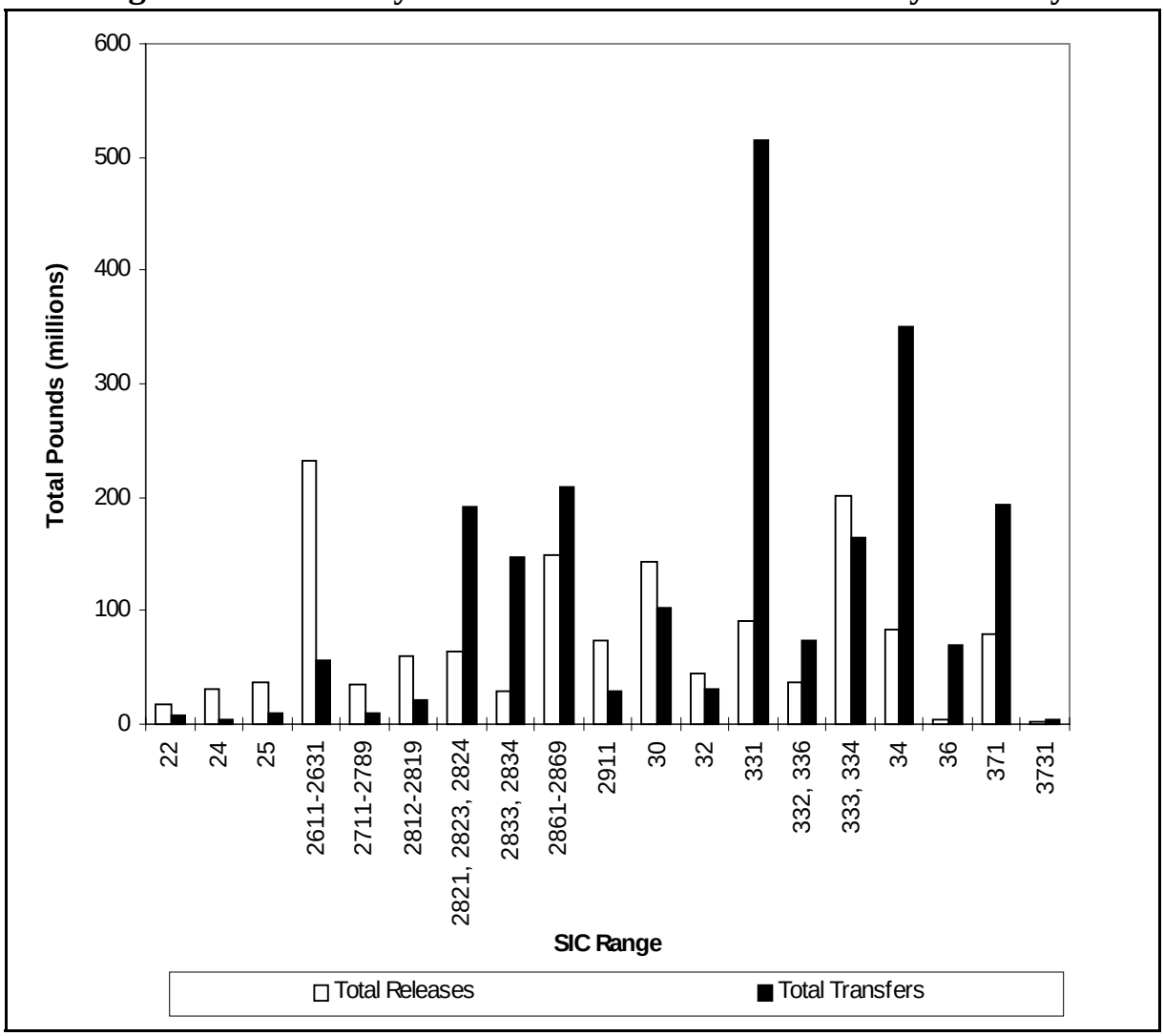
IV.D. Comparison of Toxic Release Inventory Among Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of releases and transfers within each sector profiled under this project. Please note that the following figure and table do not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release Book.

Figure 12 is a graphical representation of a summary of the 1995 TRI data for the pharmaceutical industry and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the vertical axis. The graph is based on the data in Table 19 and is meant to facilitate comparisons among the relative amounts of releases, transfers, and releases per facility both within and among these sectors. The reader should note, however, that differences in the proportion of facilities captured by TRI exist among industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of the pharmaceutical industry, the 1995 TRI data presented here covers 200 facilities. Only those facilities listing primary SIC codes falling within SIC 2833 and 2834 were used.

Comparisons of the reported pounds released or transferred per facility in Table 19 demonstrate that the pharmaceutical industry is above average in its pollutant releases and transfers per facility when compared to other TRI industries. Of the twenty manufacturing SIC codes listed in the TRI database, the mean amount of pollutant release per facility (including pharmaceutical facilities) was approximately 101,000 pounds. The TRI releases of the average pharmaceutical facility (SIC 2833 and 2834) were 150,000 pounds, making the industry 1.5 times higher in per facility releases than for other industries. For transfers, the mean of pharmaceutical facilities was about 4.6 times as much as that of all TRI manufacturing facilities (161,000 pounds transferred off-site per facility compared to 736,000 pounds per pharmaceutical facility). This comparison is difficult to interpret due to the divergent nature of the industries listed in Table 19 and the differences in the raw materials and processes used to manufacture the specific industry's products. The batch nature and large volumes of raw materials used to produce the relatively small amounts of high purity pharmaceutical products may account for the higher rate released and transferred by the pharmaceutical industry.

Figure 12: Summary of TRI Releases and Transfers by Industry



Source: US EPA 1995 Toxics Release Inventory Database.

SIC Range	Industry Sector	SIC Range	Industry Sector	SIC Range	Industry Sector
22	Textiles	**2833, 2834**	**Pharmaceuticals**	333, 334	Nonferrous Metals
24	Lumber and Wood Products	2861-2869	Organic Chem. Mfg.	34	Fabricated Metals
25	Furniture and Fixtures	2911	Petroleum Refining	36	Electronic Equip. and Comp.
2611-2631	Pulp and Paper	30	Rubber and Misc. Plastics	371	Motor Vehicles, Bodies, Parts, and Accessories
2711-2789	Printing	32	Stone, Clay, and Concrete	3731	Shipbuilding
2812-2819	Inorganic Chemical Manufacturing	331	Iron and Steel		

2821, 2823, 2824	Plastic Resins and Manmade Fibers	332, 336	Metal Casting

Table 19: Toxics Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	TRI Releases		TRI Transfers		Total Releases +Transfers (million lbs.)	Average Releases + Transfers per Facility (pounds)
			Total Releases (million lbs.)	Ave. Releases per Facility (pounds)	Total Transfers (million lbs.)	Ave. Trans. per Facility (pounds)		
Textiles	22	339	17.8	53,000	7.0	21,000	24.8	74,000
Lumber and Wood Products	24	397	30.0	76,000	4.1	10,000	34.1	86,000
Furniture and Fixtures	25	336	37.6	112,000	9.9	29,000	47.5	141,000
Pulp and Paper	2611-2631	305	232.6	763,000	56.5	185,000	289.1	948,000
Printing	2711-2789	262	33.9	129,000	10.4	40,000	44.3	169,000
Inorganic Chem. Mfg.	2812-2819	413	60.7	468,000	21.7	191,000	438.5	659,000
Plastic Resins and Manmade Fibers	2821,2823, 2824	410	64.1	156,000	192.4	469,000	256.5	625,000
Pharmaceuticals	**2833, 2834**	**200**	**29.9**	**150,000**	**147.2**	**736,000**	**177.1**	**886,000**
Organic Chemical Mfg.	2861-2869	402	148.3	598,000	208.6	631,000	946.8	1,229,000
Petroleum Refining	2911	180	73.8	410,000	29.2	162,000	103.0	572,000
Rubber and Misc. Plastics	30	1,947	143.1	73,000	102.6	53,000	245.7	126,000
Stone, Clay, and Concrete	32	623	43.9	70,000	31.8	51,000	75.7	121,000
Iron and Steel	331	423	90.7	214,000	513.9	1,215,000	604.6	1,429,000
Metal Casting	332, 336	654	36.0	55,000	73.9	113,000	109.9	168,000
Nonferrous Metals	333, 334	282	201.7	715,000	164	582,000	365.7	1,297,000
Fabricated Metals	34	2,676	83.5	31,000	350.5	131,000	434.0	162,000
Electronic Equip. and Comp.	36	407	4.3	11,000	68.8	169,000	73.1	180,000
Motor Vehicles, Bodies, Parts, and Accessories	371	754	79.3	105,000	194	257,000	273.3	362,000
Shipbuilding	3731	43	2.4	56,000	4.1	95,000	6.5	151,000

Source: *US EPA Toxics Release Inventory Database, 1995.*

V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways, such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and employing substitution of toxic chemicals. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

The Pollution Prevention Act of 1990 established a national policy of managing waste through source reduction, which means preventing the generation of waste. The Pollution Prevention Act also established as national policy a hierarchy of waste management options for situations in which source reduction cannot be implemented feasibly. In the waste management hierarchy, if source reduction is not feasible the next alternative is recycling of wastes, followed by energy recovery, and waste treatment as a last alternative.

In order to encourage these approaches, this section provides both general and company-specific descriptions of pollution prevention activities that have been implemented within the pharmaceutical industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in beginning their own pollution prevention projects. When possible, this section provides information from real activities that can be, or are being, implemented by this sector -- including a discussion of associated costs, time frames, and expected rates of return. This section provides summary information from activities that may be, or are being implemented by this sector. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must be examined to determine how each option affects air, land and water pollutant releases.

The bulk manufacturing processes of the pharmaceutical industry are characterized by a low ratio of finished product to raw material. Therefore, large quantities of residual waste are generated, especially in fermentation and natural product extraction. Chemical synthesis processes generate wastes containing hazardous spent solvents and reactants, combined with residual wastes such as reaction residues. Equipment cleaning water and residue, often containing hazardous chemicals, also are a major waste stream (U.S. EPA, 1991).

Source reduction is one method by which the industry aims to reduce these wastes. However, source reduction methods such as process modifications and material substitutions may not be as easily implemented in the pharmaceutical industry as in other manufacturing sectors. This is because any significant change to the production process of an existing product, may need approval from the Food and Drug Administration (FDA). If a company wishes to change the method of making a drug or active ingredient that goes into it, the FDA requires the company to prove that the 'new' drug is of the same or better quality as the old drug and that any reformulation will not adversely affect the identity, strength, quality, purity, or bioavailability of the drug. The process of gathering information to support the change and awaiting FDA review and approval can be lengthy, time-consuming and expensive.

As a result, many pharmaceutical companies are looking at ways to minimize waste in future production processes at the research and development stage. Incorporating pollution prevention at the start of a new drug development process is much more economical, efficient, and environmentally sound (see Section VI. D. for further details). The factors affecting the pharmaceutical industry's pollution prevention efforts were documented by PhRMA members in a 1997 document entitled *Pharmaceutical Industry Waste Minimization Initiatives*.

Many pharmaceutical companies have already implemented pollution prevention programs in their manufacturing facilities. Although pollution prevention may not always be a substitute for control technologies, it is often viable and is an increasingly popular method for meeting environmental compliance requirements. Some examples of innovative waste reduction programs that incorporate source reduction as well as recycling and reuse are presented in the case studies that appear in this section.

V.A. Material Substitutions

Substituting raw materials to lessen the volume and/or toxicity of waste generated is a type of source reduction (U.S. EPA, 1991). One of the most common opportunities for material substitutions in the pharmaceuticals industry is found in the tablet coating process. Until recently, many tablet coating operations involved the use of methylene chloride and other chlorinated solvents. By switching to aqueous-based coating films, many firms have reduced the hazardous waste content in their air and effluent waste streams, as well as the cost of purchasing chemicals. Aqueous-based cleaning solutions are also being used more frequently for equipment cleaning instead of solvent-based solutions (U.S. EPA, 1991).

POLLUTION PREVENTION CASE STUDIES

Material Substitution

- Schering-Plough Pharmaceuticals will market a new inhaler for the treatment of asthma, which is free of chlorofluorocarbons (CFCs). The CFC-free inhaler was developed by 3M Pharmaceuticals. CFCs are used as a propellant in metered-dose inhalers (MDI). In a new MDI, which was approved by the FDA in August, 1996, CFCs have been replaced by hydrofluoroalkane-134a (HFA-134a). Unlike CFCs, HFA-134a does not deplete the ozone. The product will be marketed under the brand name Proventil® HFA.

- Schering-Plough Laboratories is switching to a coated natural kraft (CNK) paperboard for its packaging. CNK is stronger and less expensive than the previous packaging material, as well as recyclable and compostable. The paperboard is not bleached with chlorine, but is coated with white clay coating. Instead of mineral-based varnishes and inks, water and soy-based materials are used. In New Jersey alone, the company is expected to save $225,000 per year and could save up to $1.2 million if the program expands to other divisions.

- At its West Point, PA, facility, Merck removed 1,1,1-Trichloroethane (TCA) from its production operations. TCA was used in stripping labels off bottles and other cleaning operations, printing, and manufacturing. A citrus-based solvent was substituted for cleaning packaging equipment. For cleaning manufacturing equipment, a petroleum-based solvent was substituted, the waste from which is used for energy recovery in an off-site facility.

- At the same facility, Merck substituted phenol for thimerosal, a mercury-based compound. Thimerosal had been used as a biocide to inactivate bacteria during the initial stages of fermentation in the production of a vaccine. Substituting phenol, a less-hazardous, FDA-approved biocide enabled Merck to achieve an 85 percent reduction in mercury-based waste. In addition, the substitution resulted in increased product yields, improved microbial kinetics, and cost savings for raw materials.

- At its Cherokee plant in Riverside, PA, Merck developed an innovative new manufacturing chemistry which substitutes toluene for dichloromethane. The change has resulted in a 98 percent reduction in releases and transfers of dichloromethane. In addition, because toluene is less volatile and more easily recovered, the controls and recovery equipment on the new process are able to control toluene releases such that they have increased only slightly.

Material Substitution (cont.)

- Riker Laboratories in Northbridge, CA recently replaced several different organic solvent coating materials used on medicine tablets with a water-based coating material. Differences in the new coating material required that new spray equipment be installed. However, the company saves $15,000 per year not purchasing these organic solvents and determined that $180,000 in pollution control equipment was no longer needed. They estimate that the investment will pay for itself in less than one year. The substitution prevents 24 tons per year in organic solvent emissions, reduced exposure risks to workers, and has made it easier for the company to comply with strict California air emission standards.

- In producing the anti-viral drug 6-aminopenicillanic acid, Bristol-Myers Squibb used to extract the intermediate, penicillin V from an aqueous fermentation broth. The broth was filtered and the intermediate then was extracted in several centrifuge steps using the toxic solvent methyl isobutyl ketone (MiBK). The extraction was a major source of fugitive emissions. The broth now is filtered through a membrane and the intermediate is extracted using n-butyl acetate, a non-toxic chemical, in closed centrifuges, reducing fugitive emissions. The overall capital investment for this project came to almost $10 million. However, the annual operating cost reductions, coupled with a 10 percent increase in throughput, generate $4.9 million in additional cash flow. Based on this, the project will generate a return on investment of 28 percent and a payback period of 2.7 years. In addition the project reduced hazardous waste by 20,000 pounds and eliminated over one million pounds of MiBK releases to the air and water.

- Glaxo-Wellcome, Inc. developed an innovative aqueous coating method that eliminated the use of methylene chloride, isopropyl alcohol, methanol, and ethanol in their Zantac tablet coating operations performed at their Zebulon, North Carolina facility. Glaxo-Wellcome overcame a number of obstacles before using the aqueous-based coating material on the Zantac production line. First, the pharmaceutical active readily degraded at the extreme heat and moisture encountered during aqueous coating. Also, the pharmaceutical active migrates through the aqueous coating causing discolorization and degradation of the tablet coating film. To implement the use of the substitute materials, Glaxo-Wellcome had to make extensive changes to the coater spray assemblies, revamped the coater air handling system with larger fans and heating coils, and installed a dehumidifying system. The capital investment for this equipment was $1.5 million. However, the company annually saves $286,800 in organic solvent purchases and $322,900 in disposal costs of the more than 479 tons of hazardous waste generated by the old system every year. The estimated payback period for the modifications is three years. In addition, the new system cut VOC emissions to the air from almost 15,000 pounds per year to zero.

Material Substitution (cont.)

- The Pharmacia and Upjohn, Inc. Sterile Manufacturing area in Kalamazoo has received FDA approval for a Thimerosal-free formulation of one of its products. This new formulation will eliminate the use of Thimerosal, a mercury based preservative, in the manufacture of the drug Atgam. Atgam will be manufactured without any preservative using new closed column chromatography and Restrictive Access Barrier technology. Atgam is used to prevent organ transplant rejection and in the treatment of aplastic anemia.

- The Eli Lilly Cleaning Technology Center in late 1996 initiated a formal screening program to identify potential aqueous based cleaners as replacements for the various organic and chlorinated solvents currently used in bulk pharmaceutical manufacturing equipment cleanings. In one product line, 8,700 liters of acetone per cleaning was replaced with an alkaline aqueous based cleaner for an estimated annual reduction of 17,400 liters of acetone. An acid aqueous based cleaner replaced methanol in another product line, resulting in methanol reductions of 25,800 liters per year. In cleaning operations associated with another product, an alkaline aqueous based cleaner replaced 117,000 liters of methanol and 600 liters of ethylene dichloride per cleaning. This resulted in an estimated annual reduction of 368,000 liters of methanol and 1,200 liters of ethylene dichloride.

V.B. Process Modifications

Process modifications are alterations to or modernization of existing processes to reduce waste generation. Process modifications can involve re-designing chemical transfer systems to reduce spillage and other material losses. For example, in batch operations, each loading and unloading of the reactors and other equipment increases the risk of chemical spills and solvent vapor releases. Batch operations often require more frequent reactor clean outs using significant volumes of cleaning solution and solvents. With continuous operations, the reactor is loaded once and solvents and reactants are fed into the reactor continually, thereby reducing the risk of pollutant releases (US EPA, 1991).

Thus switching from batch to continuous operations for certain products may potentially reduce large volumes of wastes. Switching to a continuous or partially continuous process may be possible for a facility that is the primary producer of a product which is in constant demand. For example, Hoffmann La Roche's facility in Nutley, NJ is one of the primary producers of Vitamin E in the country. Consequently, much of their vitamin production equipment is dedicated and run as semi-continuous operations.

Process changes that optimize reactions and raw material use can reduce waste and releases to the environment (US EPA, 1995). Modifications as simple as careful monitoring of reaction parameters (temperatures, pH, etc.) can dramatically improve manufacturing efficiency. Production in many of the large pharmaceutical companies is computerized and highly automated. Computers equipped with computer aided design (CAD) programs visually simulate the production process on the screen. The automated system allows production managers to turn on the batch process and control temperatures, pressure, and other process parameters, from the keyboard. While, the system runs, production personnel are free to do other things such as check equipment or take product samples. Such careful automated monitoring may insure against the formation of fouling waste at the bottom of reactor vessels, thereby reducing the need for additional cleaning, as well as lessening the risk of damaged batches of product which have to be disposed (US EPA, 1991).

POLLUTION PREVENTION CASE STUDIES

Process Modifications

- As part of their "Environment 2000" program, Bristol-Myers Squibb has started to look at Product Life Cycle (PLC) management as a way to implement pollution prevention. PLC involves investigating the environmental impacts of a product at every stage of production: R&D, manufacturing, and packaging. Pollution prevention options are now being investigated at the very beginning of drug development. This eliminates the possibility of lengthy Supplementary Drug Approval applications with FDA. Using PLC management, Bristol-Myers Squibb discovered the use of a filtration membrane for their 6-aminopenicillanic acid production (see Section V.A. Case Studies).

- At its East Hanover, NJ facility, Sandoz Pharmaceutical Co. changed processes in its reactors, to reduce solvent usage. An inert atmosphere above the reaction mixture is used during synthesis to protect the reaction from exposure to oxygen. In the previous process, nitrogen flowed continuously over the mixture, carrying away with it a certain amount of solvent vapors. The nitrogen gas blanketing process uses a non-flowing nitrogen layer that only bleeds out a very small amount of nitrogen and solvent.

- In their main drug development lab in Tippecanoe, IN, Eli Lilly and Company has implemented a pollution prevention program. Beginning in the R&D phase, the company assesses the environmental impacts of every new product and determines where wastes can be minimized. As a result, Eli Lilly developed a new process which eliminated the use of methylene chloride, aluminum wastes, use of an odoriferous raw material, and all distillation steps from production of a drug under development for the treatment of osteoporosis.

- One of Hoffmann La Roche's major manufacturing processes uses glycol ether as an extractive solvent, much of which had to be disposed of as wastewater. After the product is recovered, the glycol ether is distilled and reused. The overhead from the distillation is primarily water with some glycol ether which is disposed as wastewater. The process was redesigned to increase per pass recycle of the glycol ether in the distillation column by 12%. As a result, use of the chemical was reduced by about 60% and solvent releases decreased by 300,000 pounds per year and the batch cycle time was reduced by four hours. Annual savings are $250,000.

Process Modifications (cont.)

- At one of its facilities, Hoffman La Roche was using 110,000 gallons of methanol per year for cleaning equipment during product changeovers. Methanol was being used for all cleaning and rinsing stages. To reduce methanol usage and the associated waste disposal costs, a new method was developed whereby a two-stage water-based cleaning is done before a final methanol rinse. This reduced the amount of methanol used to about 30,000 gallons per year and saves about $49,000 per year.

- In one of its manufacturing processes, Hoffman La Roche extracted a synthesized pharmaceutical intermediate from toluene into water, and then from water into chloroform. Because toluene was soluble in the extraction, it contaminated the chloroform and created a waste stream of the mixed solvents. The company eliminated the waste stream by steam-distilling the toluene from the water so that the toluene never came in contact with the chloroform. Chloroform use decreased by 76 percent which was sufficient to remove this material from the list of chemicals the facility was required to include in its Toxic Release Inventory report. The project saved $22,000 per year.

- At its West Point, PA facility, Merck Co. made a simple change in the sequence of process steps used to manufacture a vaccine, which resulted in a substantial reduction of mercury-based wastes. Thimerisol, a mercury-based chemical, was used as a preservative during an intermediate process step. Thus any waste stream produced during the rest of the process was contaminated with mercury. A process change was initiated to add thimerosal at the end of the process. By elimating mercury in waste streams generated prior to the addition of thimerisol, mercury contaminated wastes generated during manufacturing were dramatically reduced.

- At its Flint River plant in Albany, Georgia, Merck used steam jets to produce a vacuum in the process vessel during the production of an antibiotic. This results in dichloromethane being mixed with steam and subsequently evaporating into the air. The steam jets were replaced with liquid ring vacuum pumps which reduced air emissions. Dichloromethane emissions were further reduced by maintaining the vacuum pump seal fluid at subzero temperatures which condenses the dichloromethane vapor so it can be recycled and reused.

- Pharmacia and Upjohn's wastewater treatment process was modified to significantly reduce waste disposed by its Underground Injection Control operation. A modification suggested by an employee eliminated about 1 million pounds of solid waste. This modification involved substituting a bag filter for a precoat vacuum filter. The precoat vacuum filter used a diatomaceous filter medium, which generated large volumes of solid waste. The bag filter creates much less waste per volume of liquid filtered. The used filter bags are incinerated on site, thereby greatly reducing landfill wastes.

Process Modifications (cont.)

- In converting to a new process for bioconversion of a steroid intermediate, Pharmacia and Upjohn, Inc. has eliminated approximately 90,000 pounds of dimethylformamide waste and approximately 190,000 pounds of filter aid waste per year. In addition, solvent handling was reduced from about 6 million pounds to about 600,000 pounds and aqueous waste was reduced more than 4 million pounds per year.

V.C. Good Operating Practices

One of the easiest and most economical ways to achieve source reduction is to implement good operating practices. Pharmaceutical companies already follow a list of Good Manufacturing Practices (GMP) guidelines outlined by the FDA. In some cases these involve good operating practices that will reduce raw materials use and waste generation. As a result, many companies have developed environmental policies for all of their facilities, both in the U.S. and abroad. Typically, policies may be written for employee training, employee health and safety, hazardous chemical spill cleanup procedures, equipment maintenance procedures, leak detection, and emergency response procedures.

Management commitment. Good operating practices start with on-site commitment and understanding of the need and methods for pollution prevention, from top management levels to the plant floor. Without facility-wide efforts to reduce pollution, source reduction may not be successful (US EPA, 1991).

Employee training. An employee training program is essential to the success of a source reduction program. Employees should be trained in safe handling of equipment, chemicals, and wastes. They should also be informed of any potentially harmful health effects of the hazardous chemicals they handle. As well as being trained in proper operation of equipment and chemical handling, employees should be trained in spill cleanup and methods for detecting chemical releases (US EPA, 1991).

Maintenance programs. Maintenance programs should target both preventive and corrective maintenance of equipment. This means that equipment should be regularly checked and cleaned to insure its proper functioning, and damaged equipment should be repaired quickly. Routine cleaning, minor adjustments, testing and replacement of parts, should be a part of the maintenance program. Additionally, good record keeping of equipment checks, repairs, cleaning, and equipment failure will help to reduce the likelihood of future equipment breakdowns and any associated pollution releases (US EPA, 1991).

Inventory control. The wide range of chemicals used in the pharmaceutical industry makes it essential to instigate an efficient inventory tracking system, such as a "first-in, first-out" policy and chemicals must be properly labeled with their name, date of purchase, and date of expiration. This helps to insure that older, un-used chemicals do not have to be needlessly discarded (US EPA, 1991). In addition, having one person responsible for the distribution of chemicals and supplies insures a more efficient tracking system (US EPA, 1995). Inventory tracking is a valuable and easy method for reducing wastes.

Spill prevention and storage. Spill and leak prevention are critical to pollution prevention. Tightly secured storage tanks are a key to avoiding spills. Containers should have good valves with tight stopping devices to avoid the spilling or dripping of hazardous chemicals. Storage containers should have legible signs indicating the contents of the container, health hazard warnings (where necessary), and spill cleanup procedures in case of emergencies. Large drums can be raised above the ground to avoid corrosion. An organized storage area facilitates fast and easy removal of chemicals, as well as reduction and cleanup of spills (U.S. EPA, 1991).

POLLUTION PREVENTION CASE STUDIES

Good Operating Practices

- At its Kenilworth, NJ facility, Schering-Plough Pharmaceuticals has a central warehouse with a computerized inventory system. Raw materials come into the warehouse in large volumes. Materials are weighed according to batch requirements, labeled, and then sent to different process areas throughout the facility. This eliminates excess raw material wastes and ensures that only the amounts needed are used.

- Sandoz Pharmaceuticals has also developed a system to improve scheduling of batch operations in their facilities worldwide and domestically. Accurate scheduling reduces the chances of excess wastes and costs, which occur when a batch changeover takes place.

- At its Nutley, NJ plant, Hoffmann La Roche was able to identify and repair more than 900 sources of fugitive emissions. In addition, the company installed ultra-low temperature condensers to remove solvents from vent streams. The captured solvents are recycled or treated off-site.

- The Pharmacia and Upjohn, Inc. Puerto Rico Technical Operations group was the first offshore location to implement the company's pollution prevention program. The local pollution prevention team helps the plant set pollution prevention goals. The team reports progress toward meeting goals annually. As a result, the Butyl Alcohol recovery efficiency at the facility has been increased to 95% and Acetone to 96%. The facility has been tracking waste indices (Tons of waste generated vs. Kilograms of product produced) and results for several wastes show reductions over a four-year period. The pollution prevention program has been fully implemented at all Pharmacia and Upjohn U.S. sites. Under the program individual business units set goals and report on progress annually. More than 300 pollution prevention projects, many of them in the research and development areas, have been recorded since the program started in 1990.

- The Chemical and Fermentation operation at Pharmacia and Upjohn, Inc. in Kalamazoo has begun using interlocked valve systems on jacketed coolers. The new valve systems help prevent the inadvertent discharge of methanol, used as refrigerant, to surface waters. They also have begun using new drip-less pipe couplers to reduce solvent losses and spills from hose connections.

V.D. Recycling, Recovery, and Reuse

"Recovery and recycling include direct reuse of waste material, recovering used materials for a separate use, and removing impurities from waste to obtain relatively pure substances" (EPA 1991). Although "strict quality control requirements of the pharmaceutical industry often restrict reuse opportunities, some do exist" (EPA 1991) and are considered valuable by the industry since they reduce the volume of raw materials used and the amount of waste generated and disposed.

Except for in-process recycling, EPA does not consider recycling, recovery, and reuse to be source reduction techniques. However, in-process recycling, which includes the reuse or recirculation of a chemical within a process and may include recovery or reclamation, is considered a source reduction technique. The pharmaceutical industry often uses this form of recycling which is dedicated to and physically integrated with the pharmaceutical manufacturing process by means of piping or another form of conveyance.

Recycling and recovery provides the pharmaceutical industry a great opportunity to reduce the volume and toxicity of spent solvents. As described in Section 3, solvents are used for a wide range of applications, from synthesis, extraction, and purification of active ingredients to cleaning process equipment. The types of solvent recovery employed include distillation, evaporation, decantation, centrifugation, and filtration. However, limitations exist with both on and off-site recycling and recovery since several types of solvents (including water), reactants, and other contaminants may be present. These materials must be extracted to allow the solvent to be reused either in a pharmaceutical process or in another process. Additionally, special techniques and equipment must be used to break azeotropes formed during the chemical reactions.

In addition to solvents, some residual wastes may also be recovered and reused. For example, filter cakes from fermentation processes are usually disposed of in landfills. An alternative being used in some facilities is to collect the waste filter cakes, recover any valuable by-products, and then sell the cakes to be used as fertilizers or soil additives. To be used as a fertilizer, the nitrogen, phosphorus, and potassium content must be greater than 5%, which sometimes can be achieved by reducing the moisture content in the filter cake (US EPA, 1991).

POLLUTION PREVENTION CASE STUDIES

Recycling, Recovery, and Reuse

- Nycomed Inc. manufactures bulk pharmaceutical products by batch processing. In processing a product for medical diagnostic imaging, the company installed closed loop distillation units to recover all of its methanol washes and methanol-containing wastewater. The methanol recovery system can distill approximately 2,000 gallons per day of 70 percent methanol to more than 99.5 percent methanol, which can be reused in the same process. Nycomed Inc. eliminated water discharges of methanol, reduced hazardous waste, and saved approximately 680,000 pounds of methanol in the first half of 1992, saving $54,438 in the same period.

- The Pharmacia and Upjohn, Inc. Chemical and Fermentation operation in Kalamazoo reuses more than 195 million pounds of solvent annually. Approximately 80% of the site's total solvent requirement and 90% of the site's chlorinated solvent requirement is met by reused solvent. The reused solvent demand is met through a combination of in process solvent reuse (150 million pounds) and distillation (45 million pounds). There are now six centralized distillation units. On site solvent reuse and recovery in chemical processes helped the company exceed its 33/50 Program goals. The achievement was commemorated by a National Performance Review Environmental Champion Award given to the company by Vice President Al Gore in 1995.

- Pharmacia and Upjohn, Inc. Chemical Process Research and Development developed a proprietary distillation process for splitting Tetrahydrofuran from a mixture of alcohol, water, and other wastes. Without the new process, Tetrahydrofuran forms azeotropic mixtures with alcohol which cannot be distilled. This process now recovers approximately 1 million pounds of THF per year.

- Pharmacia and Upjohn, Inc. is evaluating the possibilities of reusing waste solvent condensate produced from their cryogenic air pollution control equipment. They have identified one methylene chloride rich stream to recover as a trial. An estimated 2.5 million pounds of this waste solvent is generated annually. Recovery by an off-site recycler or on site reclamation are being further evaluated.

V.E. Pollution Prevention Research

Because of comprehensive regulations from both the FDA and the EPA, pharmaceutical companies are continuously researching new and innovative ways to reduce their wastes. Many companies are starting to look at pollution prevention options early in development and are collaborating with universities and other research institutions to develop new technologies that will help reduce or eliminate wastes. Some of these technologies, still in the research and testing stages, are discussed below.

Solvent Minimization

One potential research area which has been identified is in supercritical solvents. Supercritical fluids are known to be very effective solvents and can function as an alternative to traditional chlorinated and other toxic solvents used in pharmaceutical separations. These solvents are in a supercritical state, meaning that they are at a very high temperature and/or pressure. A relatively small change in the temperature and/or pressure in supercritical state can lead to large changes in the solubility of chemicals in the solvent. This increase in solubility is ideal for separations because the overall volume of solvent needed is reduced (NJIT, 1991).

Separation Improvements

Separation of active ingredients from solvents is one of the most important processes in the pharmaceutical industry. Research has been conducted to find separation methods which generate fewer by-products and less waste.

One technology with such a potential is inorganic membrane reactors. "They are in effect reactors with built-in separators which may have potential for reaction sequences with much better reactor utilization and product concentrations" (NJIT, 1991). Inorganic membranes enable a continuous removal of product and a controlled addition of reactant. This increases the potential for higher yields and greater selectivity by chemicals, which could reduce the volume of solvents required, thereby reducing costs and wastes. Also, because the reaction and separation are combined in a single step, the emissions associated with the traditional transfer step between reaction and separation are eliminated (NJIT, 1991).